

## **High school students' beliefs about the extent to which actions might reduce global warming**

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### **KEYWORDS:**

Education, Global Warming, Student's ideas, Misconceptions

### **ABSTRACT/SUMMARY**

The ideas of almost 600 high school students between the ages of 11 and 16 have been investigated using a closed questionnaire to find out the extent to which they believed that various actions might help towards reducing global warming. A large majority of students recognised that a reduction of industrial and vehicle emissions could play an important role, as could the use of renewable sources of energy. Fewer of the students thought that actions by individuals, such as 'saving' electricity and recycling paper, would help, and this might be due to a sense of detachment and helplessness vis-à-vis this issue. The research also highlighted a number of important misconceptions; in particular, a high proportion of students believed that a reduction of the use of nuclear power would diminish global warming, and a rationale is suggested for this and other prominent misunderstandings. Given that global warming is a complex issue, we propose that education towards the amelioration of global warming might be attempted within a taxonomic framework of *reduction, recycling, replacement and raising*.

## High school students' beliefs about the extent to which actions might reduce global warming

### INTRODUCTION

There can be little doubt as to the reality of global warming; what was at one time considered to be a debatable effect is now considered by most to be a real phenomenon ([Environmental Defence Network. 1999](#)), the reduction of which is unlikely to be easy. It will involve governments and individuals, requiring international co-operation at one level, and the engagement of the 'common man' at the other. The course of action to be taken will be costly to the individual, both in terms of financial penalties and lifestyle restrictions. As a consequence, we believe that the general public will be more likely to accept such restrictions if they understand something of the complexity of the issues, and the penalties of inaction. It has been clear for some time, however, that school and college students' understanding about global warming is severely limited and embedded with a number of glaring misconceptions ([Boyes & Stanisstreet 1993, Khalid 2001](#)).

Most children are not aware of the variety of 'greenhouse gases'; carbon dioxide, chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride, methane, nitrous oxide, ozone (at lower altitudes) and water vapour. Neither are they particularly knowledgeable about their sources.

Furthermore, they are not aware of the concept or detail of the Global Warming Potential (GWP) of gases, and their ability to trap heat in the atmosphere relative to that of carbon dioxide (methane 21, nitrous oxide 301, sulfur hexafluoride 23,900 etc). Finally, they would be ignorant of the less direct ways in which some gases affect global warming (eg atmospheric ozone and its ability to inhibit photosynthesis). Ignorance is coupled with confusion on account of the fact that some of these gases are also responsible for other major environmental problems. CFCs, for example, are potent and long-lived chemicals that have depleted the stratospheric ozone layer. To add to this complexity, some of the gases, for example ozone, are considered *beneficial*, indeed essential to life, at other altitudes. Overlaying these 'scientific' complexities are the complexities of social, behavioural, ethical and economic factors.

In order to discover students' preconceptions about the global warming, previous studies have investigated young people's ideas about the consequences, causes and cures of global warming (Boyes and Stanisstreet 1993, 2001). However, whilst these have investigated students' beliefs about what might ameliorate global

warming, they have not sought to determine what young people consider to be the relative importance of the various contributions. The research detailed here explores the ideas of high school students about these issues, their ideas about greenhouse priorities – about how we might best reduce global warming.

## **METHOD**

### *The questionnaire*

This survey used a ‘closed’ questionnaire in which high school students were asked to check boxes indicating their ideas about the extent to which various actions might reduce global warming. In order that the items in the questionnaire should reflect at least some of the thinking of children themselves, rather than just that of the scientific community, a preliminary open-form questionnaire was used with 90 students grades 6 and 8. In this, the grade 6 students were asked to write down ‘what we can do to stop the Earth warming up by global warming (the greenhouse effect)’. The grade 8 students were asked to write down ‘things that people can do themselves’ and ‘things that government and industry can do’ to reduce global warming. The items for the final ‘closed’ questionnaire were derived from popular responses to these questions and from scientific ideas, and contained 26 items; these are shown in [Figure 1](#). Correct and incorrect statements were placed randomly throughout the questionnaire, but they were all concerned with helping ‘to stop global warming’. The responses (check boxes) available were ‘a lot’, ‘quite a lot’, ‘a little bit’ and ‘not at all’. The coversheet asked students to record their grade and gender. This questionnaire was completed by 582 students in grades 6, 8 and 10 from 4 public high schools in the north west of the UK.

### *Data analysis and presentation*

Analysis was with the *Statistical Package for the Social Sciences (SPSS)*, and the results are presented as charts in [Figures 2, 3 and 4](#), the ordinate for each running from 0 to 100%, and the abscissa illustrating the three grades. In each chart, the percentages of students in grades 6, 8 and 10 giving each of the four possible responses are plotted. The lower heavily shaded area shows the percentage of those who responded ‘a lot’, the next lightly shaded area ‘quite a bit’, the white area ‘a little’, and the top lightly shaded area ‘not at all’. One can gauge the percentage of those responding ‘a lot or quite a bit’ by combining the bottom two areas, but for those responding ‘not at all’ one must mentally invert the chart. Rather than in the order in which they appeared in the questionnaire, the charts have been re-arranged so that they appear in [Figures 2, 3 and 4](#) with the most favoured first (at the beginning of [Figure 2](#)) and the least favoured at the end (at the end of [Figure 4](#)). The

numbering of each chart within a Figure relates to the items of the questionnaire, the full text and numbering of which can be seen in [Figure 1](#).

The Univariate General Linear Model was used to determine the effects of grade and gender on the distributions of responses. In addition, the responses were subjected to varimax factor analysis, to search for themes linking the questionnaire items, as determined by the students' responses. In what follows, we will focus, for ease of discussion, on the *combined* percentages for 'a lot' and 'quite a bit' (the percentages encompassing the lower two sections of each chart). In those cases where a significant difference was found across the grades ( $p < 0.05$ ), the three percentages are given in the order grade 6, 8 and 10, otherwise a single percentage figure is quoted. In those cases where there were gender differences, separate male and female percentages are given - in that order.

## RESULTS

### *High priority ideas about reducing global warming*

[Figure 2](#) shows the results for those items where over 65% of students took the view that global warming would be reduced 'a lot' or 'quite a bit' by the action; they are arranged with the most popular ideas first.

A large majority of the students believed that having fewer factories (88%) or decreasing conventional car use (79%), perhaps by using electric cars (78%) would diminish global warming. The latter was held more strongly by the male students (82%, 75%). Popular remedies for global warming were also the use of alternative energy sources, such as wind, sun and wave power, and this was increasingly so in the older students (77%, 80%, 85%). Slightly less popular were the ideas that reducing the use of coal (65%) and CFCs (54%, 67%, 79%) would reduce global warming. Despite the fact that CFCs are indeed greenhouse gases, we suspect that the predominance of this belief by students is not based on this knowledge, but rather on a confusion between global warming and ozone layer depletion ([Boyes and Stanistreet 1997](#)). There were also gender differences in the items about coal and CFCs. More males felt that reduction of coal use would be helpful (71%, 60%) and more females were in favour of a reduction of CFCs (63%, 72%). If the misconception about CFCs mentioned above is true, this implies that the males seem consistently in this section to have the more scientific view.

Major misconceptions in [Figure 2](#), amongst the high scoring questionnaire items, were those concerned with the ozone layer and the use of nuclear power. Students felt that protecting the ozone layer would help to reduce

global warming (85%), as would less use of nuclear power to generate energy (75%, 71%, 61%). The first of these relates to the confusion mentioned above, but the emphasis on nuclear energy is less obvious. Perhaps students see all things nuclear as environmentally unfriendly and link them, in an indiscriminate manner, with a range of environmental problems. Conceivably, describing nuclear waste as 'hot' may also play a role in generating this misconception. It was noticeable that more females believed that a reduction in nuclear power production would be beneficial (63%, 74%). Interestingly, the plans in Germany to limit severely the operational lives of nuclear reactors and to shut down some, as a compromise between the Social Democrats and the Greens, may be seen by some students (erroneously) as conducive to ameliorating global warming, and therefore doubly beneficial.

Finally, in this section, one of the questionnaire items was of a rather different nature in that it asked about students' views about the worth of education. Encouragingly, two thirds of the students (67%) thought that education could play an effective role here.

#### *Medium priority ideas about reducing global warming*

Figure 3 shows the charts for those items in the questionnaire for which between 45% and 65% of students believed the particular action would ameliorate global warming 'a lot' or 'quite a bit'.

The data for reducing the use of oil was similar to that for the use of coal in Figure 2 (65%), and there was a similar gender difference (68%, 62%). A comparable proportion overall thought that planting more trees would reduce global warming (64%). About two-fifths of students held the notions that reducing the number of aircraft (48%, 49%, 40%) would contribute to moderating global warming, and the idea of reducing the use of electricity (56%, 42%, 41%), an action which, unlike many of the others here, could be undertaken by individual young people, was also held by less than half of the students overall.

Disappointingly, there were some rather high-scoring misconceptions in this section. About half of the students appeared to associate dumping rubbish in rivers (60%, 53%, 37%) and marine pollution (52%, 54%, 35%) with global warming, although fewer of the older students held these ideas. Although both of these ideas diminished with age, they were more prevalent amongst the female students (41%, 53% for marine pollution and 45%, 53%

for rubbish in rivers). More than half of the students also thought that using unleaded gasoline (52%) and reducing the use of pesticides (55%) would contribute to diminishing global warming. To compound the problem, these last two misconceptions appeared stable in that the percentages did not reduce in the older students. About half of the students thought that burying waste rather than burning it would help to reduce global warming, and this idea increased slightly in the older students (46%, 57%, 57%). It is perhaps worth mentioning that decomposition of organic waste in landfill sites produces biogenic methane and carbon dioxide, both greenhouse gases.

#### *Low priority ideas about reducing global warming*

Figure 4 contains the results for the least popular ideas: those items where between 22% and 44% of students took the view that global warming would be reduced 'a lot' or 'quite a bit' by the action. The items are arranged with the most popular ideas first.

About two-fifths of students held the view that reducing the global population (35%, 52%, 42%) and having more recycling of paper (40%) would contribute to moderating global warming. Only about third of the students thought that what might be considered causes of local pollution, such as garden fires (42%, 33%, 21%), street litter (47%, 43%, 17%) or cigarette smoking (50%, 45%, 27%), were linked to global warming. Similarly, about a third of the students overall thought that the generally environmentally friendly actions of protecting endangered species (33%, 41%, 24%) or recycling materials such as glass (38%, 29%, 27%) would reduce global warming.

A disappointingly large proportion of students felt that having more air conditioning would help to reduce global warming (31%, 26%, 12%). This idea was more prevalent in the younger students and it is possible that they have a naive idea of 'cooling the earth'. This questionnaire item, which was included because it had been raised in the preliminary 'open' questionnaire, was denied ('not at all') by over half of the students (41%, 46%, 64%).

#### *Factor analysis*

Factor analysis can be used as an exploratory tool to group questionnaire items according to the way in which respondents have answered them (Child 1979), and may help to investigate connections which students are

making between ideas in each of the items. In this way, it may expose more basic themes in the way students conceptualise the issues (Boyes and Stanisstreet 1993). When varimax rotated factor analysis was applied to this data, seven factors were produced and 54% of the variance extracted. The results are shown in Figure 5. The rotated factor matrix may be interpreted by looking at each factor in turn, scrutinising the questionnaire items which have high 'loadings' on this factor, and then identifying themes common to those questions.

Factor 1 contained many of the items in Figure 4, they are erroneous but relatively unpopular and diminishing with age. Reducing marine pollution, curbing pesticide use, preventing dumping of rubbish in rivers or the streets, reducing outdoor fires, recycling glass, protecting rare species, increasing the use of air conditioning and by reducing cigarette smoking. Whilst many of these might be considered environmentally friendly actions, they are unconnected with global warming, and it appears from the trends in the charts that students increasingly realise this. We would suggest the name *less frequent misconceptions* for this factor. Factor 2 had three statements with high loadings, two of which involved reducing car use and factory-sourced atmospheric pollutants, both scientifically-based ideas. However, the third inclusion, which was also very popular, was that protection of the ozone layer would help to reduce global warming. The proximity of this item to the other two re-enforces the suggestion of a mistaken connection between the two environmental issues: global warming and ozone layer depletion.

There is a similar state of affairs with the third Factor in which correct ideas are mixed with incorrect ones. Factor 3 included the strongly held ideas that the use of electric instead of gasoline powered vehicles and the generation of energy by renewable sources would help to reduce global warming, but it also contained two idiosyncratic views. The first is the idea, mentioned above, that the depletion of the ozone layer exacerbates global warming. The other was that if less electricity was generated by nuclear power, global warming would be reduced. In fact, despite the potential environmental issues surrounding nuclear power generation, a switch away from nuclear energy would not in and of itself benefit global warming. If the switch was towards greater use of carbon-based fuels, this would increase atmospheric carbon dioxide, and thereby increase global warming. Factor 4 contained just two ideas with strong loadings, and is clearly concerned with the fossil fuels, oil and coal. The themes underlying the remaining factors are much less obvious, though we suggest tentatively that they may relate to the concept of *reduction* as a solution (Factor 5), *tree conservation* (Factor 6) and *avoiding noxious substances* (Factor 7).



## DISCUSSION

### *Some misconceptions*

The results above show a number of student ideas which appear to change with age, this is true both for scientific ideas and for misconceptions. In general, these changes correspond to an encouraging development in students' thinking, with scientific ideas increasing and misconceptions decreasing. For example, fewer of the older students thought that marine or freshwater pollution, or in littering of streets, are linked to global warming. This appears to be an example not just of increased knowledge, but also of a maturation of thinking among older students in that they show increased discrimination (Driver et al 1994). However, some misconceptions seemed to remain popular even with the older students. An example of this is the idea that using unleaded gasoline would help to reduce global warming by 'a lot' or 'quite a bit', which was consistently held by about half of the students. Similarly, more than 80% of students of all ages surveyed believed that protection of the ozone layer would help to reduce global warming to this extent. The stability of this misconception with age may be due not only to the conflation of the two environmental issues, global warming and ozone layer depletion, but also because of a logical model that students seem to employ. It is known that many believe that 'extra' solar radiation enters the atmosphere through holes in the ozone layer and then cannot escape; this gives a 'logical' explanation of global warming (Mitchell 1990, Hann 1992, Boyes and Stanisstree 1997).

### *A sense of ownership*

Many of what students consider to be the most beneficial ways of reducing global warming involve action of a corporate and cooperative nature: having fewer factories, using less coal, reducing vehicle emissions. Whilst personal vehicle use may be a part of this, there is a sense in which such actions may be considered to be outside the locus of control of individual school students, who will perhaps think that they are the responsibility of others: government, industry or big business. It is surely important to encourage students to believe that seemingly small actions can be significant, especially if routinely undertaken by many people. This may seem like stating the obvious, but in a society where even children are increasingly more individualistic and demanding of 'rights', there is a real need to engender a sense of world community and mutual responsibility within the young (Dahlberg 2001). Furthermore, students need be made more aware of the links between industrial emissions and personal lifestyle issues (Lenzen 2001), so that although the majority of carbon emissions are from industry, they relate to energy production for domestic use, the production of consumer

goods and the provision of public services (Lenzen and Smith 2000). By a combination of these means, it might be possible to encourage students to take some ‘ownership’ of the problem of global warming, demonstrating that they have both the ability and responsibility to contribute to its reduction.

#### *Moving to renewable sources*

The idea that if we used the sun, wind and waves to make more of our energy, this would help ‘a lot’ or ‘quite a bit’ to stop global warming, was also very popular amongst the students. It is perhaps encouraging that they realise that such energy from renewable sources is more or less ‘emission-free’ and ‘environmentally cost-free’, and hence an excellent solution for global warming. However, the investment required, and inevitable time delay between planning and final implementation would be significant and, if we wish to reduce carbon-based energy production quickly, there will inevitably be an ‘energy gap’. In such a period, nuclear energy, despite its obvious potential for environmental damage in other ways, might be considered to be a necessary stop-gap solution to energy requirements. On the other hand, from the questionnaire, it seems that a high proportion of students believe that reducing the number of nuclear power stations would reduce global warming ‘a lot’ or ‘quite a bit’, implying that they believe nuclear power is one of the things which exacerbate global warming.

#### *Complex problem, complex solution*

We mentioned earlier something of the complexities for students trying to understand global warming: the array of atmospheric pollutants, some exotic, and some natural but present in unnaturally high concentrations, and all coming from a variety of anthropogenic sources. The ultimate goal of education is to impart and engender knowledge and understanding which is sufficiently comprehensive that students will be in a position to make informed judgements, both about their own lifestyle but also in the way they vote for collective action. Much of the detail of global warming is likely to be potentially confusing to students. In order to help make this more accessible, perhaps it might be helpful to organise ideas so that they are presented via a ‘taxonomy’ of environmental actions, namely: *reduce*, *recycle*, *replace* and *raise*.

The need to *reduce* the use energy is probably obvious to students, but it is important to link this to an understanding of global warming in such a way that they realise that consumer goods have an energy (hence carbon) cost, so that ‘saving energy’ is not just switching off heating and lighting. Given that *reduction* is not likely of itself to be sufficient, students should be made aware of the idea of *replacing* at the point of energy

production (for example, replacing the use of fossil fuels with alternatives, perhaps even nuclear-sourced energy), and also *replacing* at the point of energy consumption (for example, replacing petroleum-based vehicles with alternatives). *Recycling* is a tangible way of helping the environment, it is accessible to the individual, the family and the school, and is popular with many students. Again, it is important for students to realise that this is not simply ‘a good thing to do’, but that it is linked to global warming, not only in the sense of saving trees which act as carbon sinks, but also in terms of a reduction in the use of energy to produce new manufactured goods. Finally, the idea of *raising*, like recycling, is seen as a positive thing to do, and activities such as tree planting can be linked in students’ minds with an increase in carbon sequestration.

Education should not only inform students but should empower them. It should give them the ability to make those daily and personal decisions that will affect their circumstances directly, and to make important decisions at the ballot box. In terms of environmental education, they should be encouraged that a range of individual actions ([EPA 2004](#)) can make a contribution, however small, to solving environmental concerns, even those problems of a global dimension.

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